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Experimental Study on Partially Concrete-filled New Type Composite Beam

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Abstract. When a load is applied to a both end fixed beam, the negative moment is approximately 1.5–2 times greater than the positive moment. The cross section of the center beam can resist efficiently with lesser moment of inertia than that of the end due to moment redistribution. Accordingly, reduction in the story height and amount of materials used can be expected. In this study, we developed a partially concrete-filled new type composite beam that efficiently resists the negative and positive moments at its end and center, respectively, and conducted tests to verify its structural performance. The partially concrete-filled new type composite beam is called the Omega beam (OMB), hereafter.

Keywords: Fixed end beam, OMB system, Partially concrete-filled, Reduction in story height

1 Introduction

We aim to find the ratio of the moments of inertia (I_1:I_2) and the value α, where I_1 and I_2 are the moments of inertia of the fixed end and center beam, respectively, and α is the ratio of the length of the reinforced span (the end beam) to the length of the beam. Fig. 1 shows the load on the OMB.

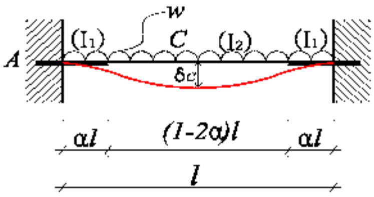

Fig. 1 OMB subjected to uniformly distributed load w

Eq.1 calculates the fixed end moment corresponding to changes in α and I_1:I_2, of the OMB on which the uniformly distributed load w acts.

$$l \quad M \oplus = \quad + \quad \langle(1\,2\,\langle) \qquad (1)$$

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When the OMB is subjected to the uniformly distributed load ω, its deflection (δ_c) can be calculated using Eq.4.

$$\delta_0 = \frac{l^4 \omega K_{do}}{24 E} \qquad (2)$$

$$K_{do} = \frac{K_{Ro}}{2} \cdots \frac{6\zeta^2 - 4\zeta^3}{I_1} \cdots \frac{1 - 4\zeta + 3\zeta^2}{(2 6} \cdots \frac{3(1-2\zeta)^2(\zeta - \zeta^2)}{-4\zeta)} \cdots \frac{3(1-2\zeta)}{2I_2 \quad 16 I_2} \qquad (2\text{-}1)$$

$$K_{Ro} = \frac{6\zeta^2 - 4\zeta^3 (1-2\zeta)}{I_1} + \frac{(1+2\zeta - 2\zeta^2)}{I_2} \qquad (2\text{-}2)$$

$$\gamma_1 = \frac{M l^2 \varphi \rho}{2E} \cdots \frac{1)}{I_2 \; I_1} \cdots \frac{\zeta^2 \; 1}{4 \zeta^2} \; 11 \qquad (3)$$

$$\delta_C = \delta_0 + \delta_1 \qquad (4)$$

Fig. 2 shows the deflection according to variation of α. We investigated the trends while changing the values of the moment of inertia of the end (I_1) is 1.2, 1.3, and 1.5, and those of the moment of inertia of the center (I_2) are 0.6, 0.7, and 0.8.

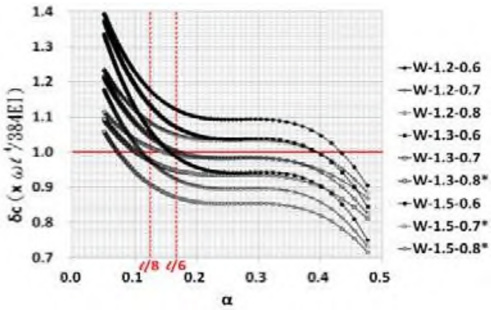
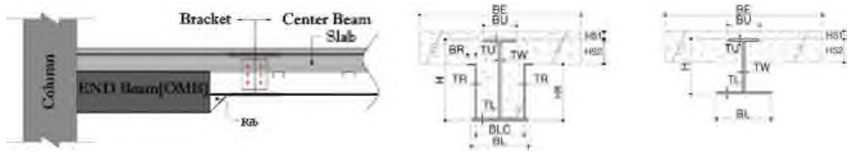


Fig.2 Variation in central deflection under uniformly distributed loads ω

2 Development of the OMB system

Through theoretical reviews, we developed the partially concrete-filled new type composite beam. Fig. 3 shows a sketch of the OMB system. Fig. 3(b) represents the end of the OMB with a cross-sectional property of I_1. Fig. 3(c) represents the center of the OMB with a cross-sectional property of I_2.



(a) Components of the OMB (b) OMB end (c) OMB center

Fig.3 OMB system

The cross-sectional code of the OMB is OMB-H x B_U x B_L x T_W x T_U x T_L x H_R x B_R x T_R.

3 Test scheme

3.1 Details of specimen

We intend to examine the followings by performing tests on the OMB system. First, the difference between the deflections of the OMB and hot-rolled H-beam (GNB), the bench marks specimens, is investigated. Second, we verify the composite effect of OMB system compared with H-beam system in which stud bolt embedded. Table 1 shows a list of the specimens.

Table 1. List of specimens

Specimen name	Slab	Shear connector	Total depth		Note
			End	Cent.	
GNB-HC	Yes	Yes	600 mm	600 mm	Bench mark of composite beam
OMB-1C	Yes	No	550 mm	400 mm	200 mm save of story height
OMB-1CT	Yes	Yes	550 mm	400 mm	200 mm save of story height
OMB-2C	Yes	Yes	700 mm	550 mm	

The end beam dimensions of GNB-H, OMB-1, and OMB-2 are H-400 x 200 x 13 x 8, OMB-500 x 200 x 350 x 6 x 11.8 x 7.8 x 350 x 50 x 3.1 and OMB-500 x 200 x 350 x 6 x 11.8 x 7.8 x 500 x 50 x 3.1, respectively. The dimensions of the center beam of the OMB's (OMB-1 and OMB-2) are OMB-350 x 350 x 6 x 11.8 x 7.8.

The span of all specimens is 9,000 mm. The bracket's length (end beam's length), is 1,125 mm. The width, length, and thickness of the concrete slab are 2,400, 8,700, and 200 mm, respectively.

3.2 Test setup and procedures

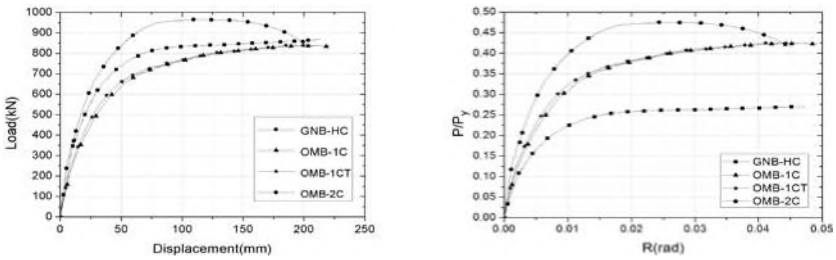
The images of the OMB setup are shown in Fig. 4.

(a) 3-D model (b) Actual setup

Fig. 4 Test setup for a typical specimen

4 Test results

Fig. 5 shows the results of the test to evaluate the structural performance of the OMB's deflection and the behavior of the composite beam with and without shear connectors.



(a) Actual test (b) Non-dimensionalized

Fig. 5 *P*–*δ* curves

5 Conclusions

Our conclusions, obtained from the experimental study of the partially concrete-filled new type composite beam (OMB), are as follows:

1. The OMB system reduced the story height by 200 mm as compared to the general composite beam system.
2. The non-dimensional initial stiffness of OMB-1C and OMB-1CT was approximately 1.4 times greater than that of GNB-HC.
3. The hysteretic behavior of OMB-1C and OMB-1CT was so similar that OMB system showed a completely composite behavior without shear connectors.

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